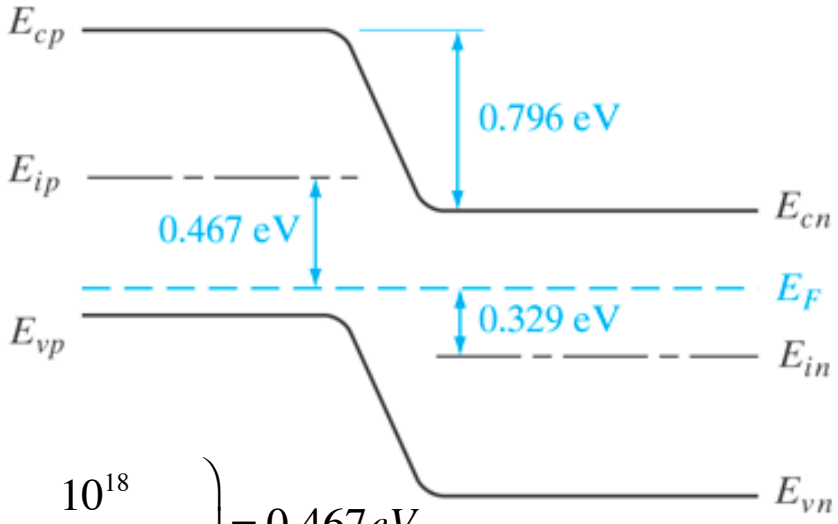
Example: Abrupt Junction

Problem:

An abrupt junction in Si has $N_a=10^{18}$ cm^{-3} on one side and $N_d=5\times10^{15}$ acceptors on the other.



(a) Calculate the Fermi level positions at 300 K:

$$p_p = n_i e^{(E_i - E_F)/kT} \text{ so } E_{ip} - E_F = kT \ln\left(\frac{p_p}{n_i}\right) = 0.0259 \ln\left(\frac{10^{18}}{(1.5\times10^{10})}\right) = 0.467eV$$

$$n_n = n_i e^{(E_F - E_i)/kT} \text{ so } E_F - E_{in} = kT \ln\left(\frac{n_n}{n_i}\right) = 0.0259 \ln\left(\frac{5\times10^{15}}{(1.5\times10^{10})}\right) = 0.329eV$$

(b) Determine the contact potential:

$$qV_o = 0.467 + 0.329 = 0.796eV$$

(c) Calculate the contact potential directly:

$$qV_o = kT \ln\frac{p_p}{p_n} = kT \ln\frac{N_a N_d}{n_i^2} = 0.0259 \ln\left(\frac{(1\times10^{18})(5\times10^{15})}{(1.5\times10^{10})^2}\right) = 0.796eV$$

Example: Abrupt Junction [2]

Problem:

An abrupt junction in Si has $N_a=10^{18}$ cm^{-3} on one side and $N_d=5\times10^{15}$ acceptors on the other. If the junction has a diameter of 10μm:

Calculate the junction area:

$$A=\pi(5\times10^{-4})^2=7.85\times10^{-7}\,cm^2$$

Assuming a junction in equilibrium at 300K, calculate the total depletion width:

$$W=\left[\frac{2\varepsilon V_o}{q}\left(\frac{1}{N_a}+\frac{1}{N_d}\right)\right]^{1/2}$$

$$=\left[\frac{2(11.8)(8.85\times10^{-14})(0.796)}{1.6\times10^{-19}}\left(10^{-18}+2\times10^{-16}\right)\right]^{1/2}=0.457\,\mu m$$

Calculate the depletion width on the n-side (x_{no}) and p-side (x_{po}):

$$x_{no}=\frac{W}{1+N_d/N_a}=\frac{0.457}{1+5\times10^{-3}}=0.455\,\mu m$$

$$x_{po}=\frac{W}{1+N_a/N_d}=\frac{0.457}{1+200}=2.27\times10^{-3}\,\mu m$$

Abrupt Junction:

$$x_{no}\sim W$$

$$x_{po}\sim W\frac{N_a}{N_d}=\delta$$

Calculate the charge Q_+ and plot the charge density:

$$Q_+=qAx_{no}N_d=qAx_{po}N_a=(1.6\times10^{-19})(7.85\times10^{-7})(2.27\times10^{11})=2.85\times10^{-14}\,C$$

Calculate and plot the electric field:

$$E_o=-\frac{q}{\varepsilon}x_{no}N_d=-\frac{q}{\varepsilon}x_{po}N_a=\frac{1.6\times10^{-19}}{(11.8)(8.85\times10^{-14})}\left(2.27\times10^{11}\right)=-3.48\times10^4\,V/cm$$